Communications Research Centre Canada
An Agency of Industry Canada
Centre de recherches sur les communications Canada
Un organisme d'Industrie Canada

Eye on Technology

ISSN 1717-7294

Issue No. 11 - Fall 2009 | www.crc.gc.ca

In This Issue...

CRC Researcher Brings Bandwidth to Polar Science

CRC's Chris Iles poses with an antenna installation enabling communications with the North.

Photo: J. Lang, PCSP/NRCan

Chris testing MEOSAR (Medium Earth Orbit Search and Rescue) satellite beacons for the next generation search and rescue system during a visit to the Arctic.

For most of us, getting up and going to work everyday is pretty uneventful. We haul ourselves out of bed, flip the switch on the coffee maker and as it burbles away, we brush our teeth and pull on office-appropriate clothing before heading out the door. But for the Communications Research Centre's (CRC) Chris Iles, Supervisor of Satellite Network Systems Integration, the beginning of the work day can be anything but routine, with an Arctic sleeping bag replacing his cozy bed, coffee brewed over a cook stove while keeping an eye on the horizon for hungry bears, and the donning of attire fit for a polar expedition.

Iles is a specialist in the design and building of cutting-edge satellite communications networks. As part of the SMART program – Satellite Multimedia Application Research and Trials Program – Iles sets up demonstration networks that bring high-end communications to people who wouldn't otherwise have access to them. His job, by necessity, takes him to some of the harshest environments on the planet, places where terrestrial communication networks are not an option.

"Most people don't understand what you can do over satellite," says Iles. "Once they can see what can be done they begin thinking of applications. The more a demonstration network can do, the more ideas people get, and the more ideas people feed us, the better the next demonstration becomes."

Iles spent several weeks in the summers of 2008 and 2009 in and around Resolute, Nunavut, developing a satellite communications network for the Polar Continental Shelf Program (PCSP). PCSP, an organization within NRCan, provides logistical and support services to research teams working in Canada's North. Among their services, PCSP supplies equipment to field-research teams, transports teams to and from remote study sites, and maintains research facilities and infrastructure at the base station in Resolute. A critical part of this research infrastructure is a communications network with the capacity and capabilities required by scientists at the forefront of polar research.

"For many of the scientists going through PCSP, it is either their last contact with the Internet before going out in the field or their first contact with the Internet after being out for weeks collecting data. They need to move serious amounts of information, either pulling it down or pushing it south."

And that, says Iles, is a problem in the Arctic where satellite infrastructure is limited and very expensive. With an average of 50 to 60 researchers in residence at PCSP at any one time, the PCSP network was working with an average upload speed was 384 kb per second for downloads, and 124 kb per second for uploads. To put that in concrete terms, it would take almost 3 hours to send a 5 MB file. Video conferencing, VoIP communications, and the transmission of large data files, including image, audio and video files, was simply not an option.

To solve the problem, Iles redesigned the network, creating several virtual networks on top of a single infrastructure. While the commercial carrier is still in place for handling the low-bandwidth applications such as e-mail and access to web pages, the high-bandwidth applications are handled by a separate virtual network which is linked, via Telesat's AnikF2 Ka band satellite, to Canada's high speed research network, CANet4, giving PCSP, for the first time ever, the bandwidth to function as a true research centre.

But setting up communications networks in the Arctic, Iles notes, has its own peculiar problems. Coaxial cable, for example, which is used to transmit high-speed signals between buildings, shatters like glass at -50 °C. And the extreme temperature changes that characterise the polar climate play havoc with connectors, as the plastics, metals and other materials expand and contract at different rates. Even the simplest of tools can have surprising properties.

"I was using a 36-inch aluminium pipe wrench to bolt down a satellite dish at about -40 °C. Because of the wind you have to really tighten these things down, so I was hauling back with all my weight when the wrench shattered in my hands and I did a back flip off the satellite dish. The only reason I wasn't hurt was the snow cushioned my fall."

While the use of industrial-grade equipment would solve at least some of the problems, the cost would render the networks impractical. "An industrial-

grade switch costs around $10,000. A normal commercial switch costs $500."

That means, says Iles, that a large part of his job is designing innovative ways to make commercial products function in these harsh conditions. In the case of the coaxial cables, that meant keeping them warm in a truck until the moment they were laid, then laying them at breakneck speed before they could freeze. For the connectors, Iles and his team designed climate-controlled boxes to protect them from the extreme changes in temperature. And the pipe wrench crisis was averted by going door-to-door in a small community to find a temporary replacement. "The great thing about working in the North is that everyone knows everyone, and everyone pitches in."

One of the hardest things, though, says Iles, is debugging the system once it's installed. Satellite networks are sensitive and complicated, each with its own individual peculiarities. Under normal circumstances it can take up to a month to thoroughly debug a system, but when working in remote areas under brutal conditions, the task must be carried out in two to three days.

While Iles' job may not sound like a picnic to those of us who like our morning double-double, Chris thrives on the challenge. "There is no one system that's best for all situations, so what I have to do is take existing hardware then I push it to its limits by either modifying it slightly, or by making it do things it was never intended to do. It's a lot of fun."

For more information contact Chris Iles, Supervisor of Satellite Network Systems Integration, at 613-998-2734 or *chris.iles@crc.gc.ca*.

CRC Antenna Design Integral to SkyWave's Success

In the early 1990s, Peter Rossiter of SkyWave Mobile Communications approached CRC's Michel Cuhaci, Manager of the Advanced Antenna Technology Research group, with the specifications for a new antenna his company wanted the lab to design. Specifications, Cuhaci remembers, that he knew would be difficult to achieve.

The small start-up company was designing a mobile satellite terminal for asset management. Their terminals, they hoped, would be placed on trucks, train cars, containers, even ships at sea, and allow fleet managers to pinpoint not only the location of that asset, but a whole host of other factors including speed and direction of travel, engine condition, cargo temperature, even what door locks had been accessed. In short, a range of parameters tied to the state and security of the vehicle and cargo. For the system to work, however, they needed an antenna that would be small enough to fit within the terminal – about the size and shape of a small smoke alarm – that would sit inconspicuously on top of the asset. But, despite its small size and flat shape, the antenna would require the power and sensitivity to communicate with a satellite 36,000 km above the equator. The final requirement was that the antenna cost less than three dollars a unit to produce.

An antenna, explains Cuhaci, is a transducer. It takes one form of energy and transforms it into another. Antennas can both radiate (transmit) and receive signals. On the transmitter side, the antenna takes an electrical signal fed to it and transforms that signal into an electromagnetic wave – the backbone of wireless communication. On the receiving end the process is reversed, with the antenna capturing the electromagnetic wave carrying the signal and

transforming it into electrical energy which can then be deciphered and processed by electronics and software.

While Cuhaci knew that SkyWave's specifications would be a challenge to achieve, he was also confident that the lab had the tools and expertise to succeed. Not only was his group the largest independent antenna research group in Canada, they boasted cutting-edge facilities for modelling, prototyping and characterizing antennas. Even more important, says Cuhaci, the lab consistently follows a two-pronged approach to research, working with clients to develop prototype antennas for their specific – and often extremely challenging – applications, while at the same time maintaining a strong program of forward thinking, visionary research.

"The work we're doing with clients today is based on research we did 10 years ago," explains Cuhaci. "We have to be ahead of the game so we have the right tools, the right technologies, when the client arrives with a new application. Otherwise it's too late."

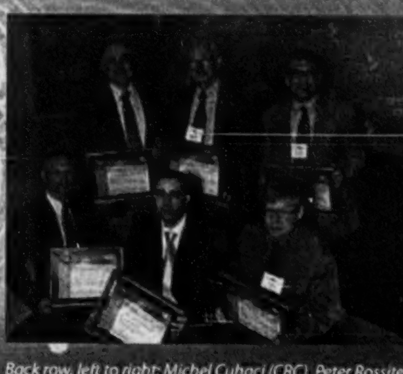
Faced with SkyWave's exacting specifications, Cuhaci's lab started by doing sophisticated modelling of the electromagnetic characteristics of possible antenna configurations. They looked at a range of possibilities, including different styles of microstrip patches, different feeds to the antenna and different antenna materials.

According to Rossiter, this shaved both time and money off the development process. "We were able to look at half a dozen configurations over a period of weeks," says Rossiter, "and predict their performance very accurately without the high cost of building and testing multiple prototypes."

Once Cuhaci and Rossiter had flagged configurations of interest, CRC's model shop built prototype antennas based on those designs. The prototypes were then tested and characterized in specialized electromagnetic-anechoic chambers, and promising candidates tweaked and retested to optimize their performance.

"Through CRC we had access to test chambers, to automated network analyzers, to calibrated test antennas. With all this, we were able to form very accurate and repeatable measurements on prototype antennas."

So accurate and repeatable, says Rossiter, that when SkyWave Mobile presented the results to INMARSAT – the satellite network consortium that SkyWave hoped would carry their signals – their terminal passed INMARSAT's stringent requirements on the first try. "Within 13 months of going to CRC we had a fully developed terminal and antenna, and INMARSAT granted us type approval."



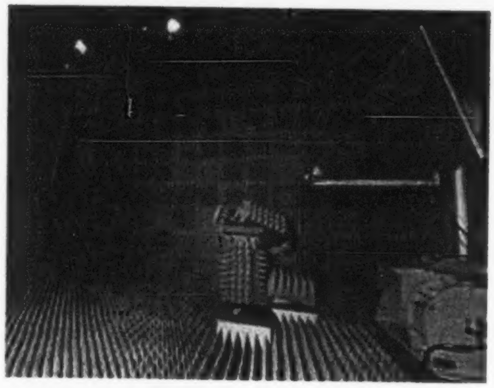
Back row, left to right: Michel Cuhaci (CRC), Peter Rossiter (SkyWave), Vadim Volinski (SkyWave); front row, left to right: Aldo Petosa (CRC), Nicolas Gagnon (CRC) and Doug Reveler (SkyWave).

On June 18, 2009, CRC and SkyWave Mobile Communications Inc. received a technology transfer award from the Federal Partners in Technology Transfer (FPTT). Skywave began with four engineers when it first joined CRC's Innovation Centre in 1997. Now a world leader in telematics products and services, it has 80 people with $50 million in cumulative sales over the last 10 years.

Eye on Technology

SkyWave is now a world leader in satellite-based mobile asset tracking systems, with over 100,000 users worldwide, $50 million in cumulative sales over the past 10 years, and a bright future ahead. A future, says Rossiter, very much tied to antenna design.

"In the next five to ten years, we're going to be looking at smaller and smaller beams, frequency re-use just like we see in cellular systems, and we're going to need more intelligent, adaptive antennas: beam formers, interference cancelling. And all of this has to be done at a ridiculously low price point," says Rossiter.



CRC's state-of-the-art antenna test facilities today.

Not surprisingly, Cuhaci's lab is focussing its long-term research efforts on precisely these types of projects. For example, says Cuhaci, his group is developing antenna designs for frequency bands that are currently not being used but, given the current overcrowding of the electromagnetic spectrum, will open up in 10 to 15 years. These high-frequency bands will likely support a new generation of medical devices for diagnosis and treatment, as well as finding use in screening and security devices. But for these applications to become a reality, he stresses, they will require antennas that can reliably send and receive information in these higher frequencies.

The lab is also working on the kind of antenna Rossiter predicts will be needed in his particular business – antennas with internal complexity able to change frequencies and orient to maximize signal strength. And, Cuhaci adds, the lab is always looking at new materials and innovative designs that will make the antennas of the future "industry friendly." One example is a project to develop flat satellite dishes. A simple change in shape – as long as performance is maintained or improved – would make the antennas easy to pack, transport and assemble.

"We're also looking at technologies for producing antennas in ways people can afford," he explains. "If you're talking about an antenna going into any consumer product, that's a big constraint." For example, the lab is investigating ways to print antennas using an ink-jet printer. "It's being done for low-cost solar cells using polymers and nano-materials printed on plastic, so maybe we can use it here."

Cutting-edge antenna design and performance, says SkyWave's Rossiter, is integral to the success of a company like his. "The antenna is where the fundamental performance of the terminal is established, to a large extent. It's where the real advantages can be had. The signal processing has to be done very rigorously in the DSP [digital signal processing] portion of the terminal, but the antenna is where the battle is fundamentally won or lost."

For more information, please contact Michel Cuhaci, Manager of the Advanced Antenna Technology Research group, at *michel.cuhaci@crc.gc.ca* or 613-998-2548.

A New CRC Video Codec Outperforms Current Video Compression Technology

As anyone involved in the electronic entertainment business knows, the viewers of today are both sophisticated and discerning. They demand high-resolution images, brilliant colours, and seamless life-like movement. To top it all off, they want content delivered where they want it, when they want it – whether that be to the rec-room HDTV, the office computer, the smart phone or hand-held gaming device.

"People want more content and more choices," says André Vincent, Manager of CRC's Advanced Video Systems group, "but at the same time, they want faster delivery and better image quality."

These new mobile technologies, he explains, paired with an increasing appetite for high-definition and 3-D video products, is putting enormous pressure on companies in the business of delivering content. Raw video requires an enormous amount of data, and the higher the resolution, the higher the data rate required to achieve the flawless image and movement that viewers demand. The higher the data rate, the more bandwidth it takes, and bandwidth is limited and expensive.

"A lot of program material is delivered by satellite before going to cable or out to your wireless device. If you can reduce the data rate, this reduces the cost of transmission."

The answer has been to develop codecs: systems that compress video for transmission then de-compress it at the viewer end. The most commonly used system is based on the MPEG standard introduced in 1993. It has continuously been refined and optimized through to the latest version, MPEG-AVC/H.264-4. Like all compression technology, the MPEG standard uses a set of


a


b


c

(a) Original picture, (b) compressed at 0.2 bit per pixel with CRC-WVC technology, and (c) compressed using MPEG-4/AVC at 0.2 bit per pixel. The quality of the picture compressed using CRC's technology is 1.3dB better than that compressed using MPEG-4/AVC.

mathematical rules to analyze, then transform the raw video data into a more condensed code. In the case of MPEG, the data is transformed using a discrete cosine transformation (DCT). The compressed data that is eventually transmitted is a set of coefficients based on this mathematical transformation. The information is then decoded at the other end to recreate the image data.

"But," stresses Vincent, "there is no magic. Compression comes at a cost and the cost is some reduction in picture quality." And, he says, while the discrete cosine transformation that the MPEG standard is based upon has served us to date, it may not be enough to provide a further 50% reduction in bit rate as expected for the next generation of video compression standard.

"All the current standards – MPEG-2 and MPEG-4 – are based on an architecture developed 20 years ago. It has been refined, adding tools and complexity with constant performance gains, but now we have to look to the future. We can either continue to tinker and make minor improvements to the MPEG technology or we can adopt an entirely new approach."

Vincent's lab decided to do the latter, using directional wavelets as the foundation for their new prototype codec, CRC-WVC.

The mathematical "transform" that one uses to analyze and code the data, explains senior scientist Demin Wang – the CRC-WVC codec developer – acts something like a filter. Each transform has its own particular properties: it picks up certain characteristics of the image while allowing other information to pass through. The trick to choosing the best and most efficient transform for video compression is to find one that picks up and codes for the information most important to viewer experience, while leaving the irrelevant bits behind.

Using a transform based on directional wavelets, says Wang, does exactly that. The traditional DCT transform used by MPEG performs a two-dimensional transform on small blocks of the image, coding changes in the horizontal and vertical axes extremely well, but performing less well on information off the horizontal or vertical axis. A transform using directional wavelets, however, is highly sensitive to unpredictability – attributes like edges moving at odd angles or curled or wavy lines – precisely the kind of information viewers are glued to as James Bond hurtles over a scaffold or the claws of a monster lash out at your character in *Final Fantasy 11*.

"We don't need to spend a lot of bits, or data, on uniform areas," explains Wang. "We just need to concentrate on important features. That's the benefit of using directional wavelets. Images that contain a lot of lines or contours are coded very precisely."

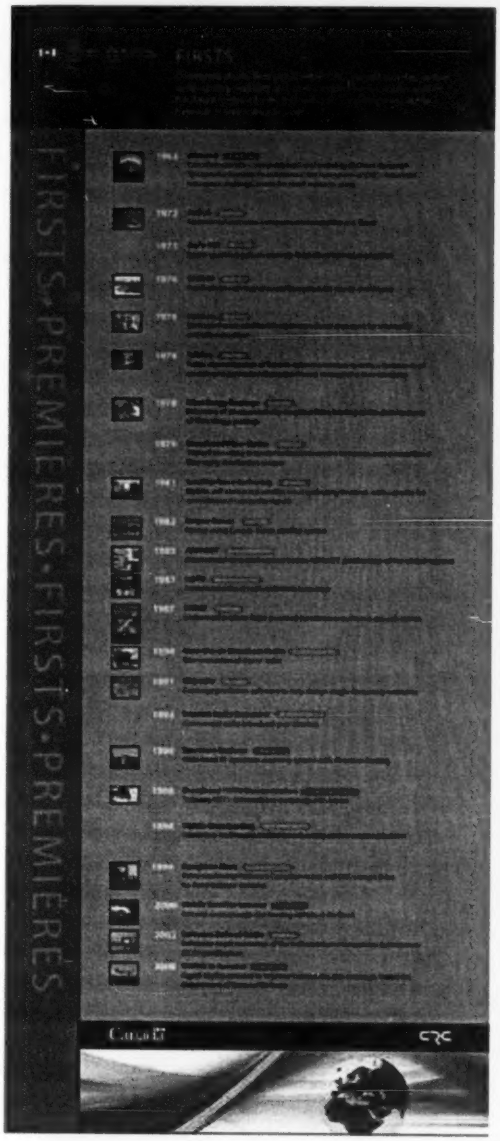
While still in the early stages of development, viewer tests are showing that the new CRC-WVC performs as well as, or better than, MPEG-4, especially on certain kinds of program material. And CRC-WVC compression efficiency, says Vincent, is especially good on high definition video sequences. In addition to video compression, the lab will also be investigating other applications for the technology in medical imaging, fingerprint analysis, and super HDTV. It can be applied, stresses Vincent, to any application where precise edge information is important.

For more information contact André Vincent, Manager, Advanced Video Systems, at *andre.vincent@crc.gc.ca* or 613-998-2299.

CRC Celebrates 40 Years at the Cutting Edge of Communications

When the Communications Research Centre (CRC) was established in 1969, the world was a very different place. Telephones sat wired to a desk or wall. There was no voice mail, caller ID, or text message service. Business documents travelled by post, overland or by air, with delays of days or weeks depending on the destination. And computers were monstrous affairs found only in select universities, research institutes and government departments. The kids at home could choose between three, or maybe four, television channels depending on the size of the TV antenna. That is, unless they lived in rural areas or the North. There, they were lucky to have reliable radio, never mind TV.

But Canada was on the cusp of change. In 1962, the Defence Research Telecommunications Establishment – the forerunner of CRC – built and designed Alouette 1, and with its astounding success proved to the world that, properly constructed, complex, delicate instruments could be sent into space and relay information for years. Then, in 1967, John Chapman, who had led the Alouette project, released his pivotal report on the future of Canada in space science. Rather than going down the same path as the U.S. and U.S.S.R., with their focus on military applications in space, Chapman urged the Government to develop a domestic satellite communications system. It would, he argued, truly serve the Canadian people and be vital to the growth, prosperity and unity of our country. In retrospect, they were prophetic words, and ones the Government heeded. They created CRC two years later.



CRC Firsts over 40 years, also posted on CRC's website at www.crc.gc.ca/firsts.

As we now know, in the 40 years of CRC's existence communications technologies have transformed our lives. They have changed the way we work, how we play, how we interact with family, friends and co-workers nationally and internationally. They have altered how we learn, how we access information and even, researchers are telling us, how our brains are wired to think. And as the technologies transform our lives we, in

turn, transform the technologies by demanding faster, smaller, more efficient technology. So much so, that the traditional domains that CRC was originally tasked to oversee – satellite, telephony and broadcasting technologies – are blending and converging in unexpected ways.

For 40 years, CRC has been at the forefront of this telecommunications revolution, foreseeing and creating the technologies that have helped make Canada, and Canadian industry, leaders in communications technology. CRC has even been honoured with two Emmy awards for outstanding contributions to satellite and television technology. Here are just a few highlights from CRC's 40-year journey.

Emmy Award-Winning Hermes Satellite

CRC's experimental Hermes satellite was designed to test a new and novel concept. Rather than sending the communications signals to large receiving stations, the researchers wanted to know if an orbiting satellite with a higher-powered and higher frequency signal could create a signal strong enough to be received by small, independent, movable dishes. This, they reasoned, might eventually lead to some kind of "direct-to-home" satellite services. Given the number of small satellite dishes on the roofs of so many houses today, it should come as no surprise that the experiment was a success. The Hermes satellite was used from 1976 to 1979, to demonstrate numerous applications including telemedicine, distance learning, and direct-to-home broadcasting. In 1978, for example, Hermes established a clear and stable telephone link to demonstrate telemedicine via satellite to northern Canadians when an x-ray of a patient was relayed from the Moose Factory General Hospital, Cochrane District, to the University Hospital in London, Ontario. The same year, Hermes also gave the world its first "direct-to-home" satellite television broadcast, when diplomats stationed in the garden of the Canadian Trade Counsellor in Peru watched a broadcast of the Stanley Cup playoff game being played in Montreal between the Canadiens and the Boston Bruins.

ARPANET

Although it is hard to imagine today, there was a time when the Internet hardly existed: when the Internet was called ARPANET, and was made up of only a few mainframe computers, mainly in the United States, linked together as an experiment. The goal of the research was to develop a system that would allow computers to communicate with each other. In 1985, CRC created the first international connection via terrestrial cable to the fledging Internet. The connection jump-started Canadian research, giving scientists and engineers the tools to experiment in areas such as network protocols, wired and wireless network infrastructure, and network applications. As a result, both researchers and Canadian companies have been at the forefront in the development of IP-based products and services. For example, CRC and CBC partnered to create the first website in the world to offer radio over the Internet.

Broadband HDTV Heart Surgery Workshop

On Friday evening, January 30th, 1998, the potential of high definition television (HDTV) to aid in patient treatment and diagnosis was on display at CRC. In a Canadian and Japanese first, through a satellite-linked high definition teleconference, surgeons in Japan demonstrated the modified Batista procedure for surgically reducing an enlarged heart. Surgeons from the Heart Institute in Ottawa demonstrated a new technique for minimally invasive cardiac bypass surgery. Both procedures were pre-taped in HD video, and through the high definition teleconference link, surgeons on both sides of the Pacific were able to view, examine and discuss, in real time, minute details of the surgical procedures.

For more information on CRC accomplishments contact *media@crc.gc.ca*

Eye on Technology

CRC Awarded

The Communications Research Centre shines not only on the research front, but in facilities management too. CRC received the "Companies for Conservation" award for its efficiency investments and innovative promotional programs like the "Amp Champ" conservation comic strip. In the last 15 years, CRC made outstanding progress in reducing energy costs by an estimated $10.5 million. CRC joins some major local establishments that have also been recognized by Hydro Ottawa.

CRC Researchers Garner Gold Paper Award at IEEE Conference

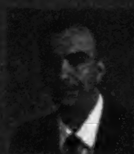
CRC researchers Geoff Colman and Tricia Willink are Gold Paper Award winners for their paper "Improving Robustness of Precoded MIMO Systems with Imperfect Channel Estimation" presented at the 2009 IEEE Pacific Rim Conference on Communications, Computers and Signal Processing, held in Victoria, B.C. in August.

Organizers presented a Gold Paper Award in each of the three subject areas – communications, computers and signal processing. The Colman-Willink paper won in the communications category.

Geoff and Tricia, both research scientists, work in the Radio Communications Technologies section of CRC's Terrestrial Wireless Systems Research branch.

CRC Welcomes Two New Vice-Presidents

On October 5 CRC welcomed two new vice-presidents: Dr. Alex Vukovic, Vice-President, Terrestrial Wireless Systems Branch; and Dr. Jean Luc Bérubé, Vice-President, Broadband Network Technologies Branch.



Alex Vukovic was most recently Senior Research Scientist with CRC's Broadband Network Technology group. He has over 20 years of experience managing R&D programs and developing broadband communications technology for industry and government. He is known internationally as a leader in promoting collaboration and partnerships in R&D. Prior to CRC, Alex served as Senior Technology Advisor for Optical Network Architectures at Nortel Networks. Alex has a Doctorate in Mechanical Engineering and a Master of Science degree in Engineering from the University of Belgrade, Yugoslavia.

Jean Luc Bérubé, who joins CRC from Altera Corporation, has over 20 years of experience in the Canadian electronics industry. He was Senior Manager, Field Application Engineering at Altera Corporation, where he was instrumental in product planning and marketing for the wireless and broadband network communications sectors. Prior to Altera, Jean Luc was Senior Field Applications Engineer and Market Development Manager for Motorola Semiconductors. Jean Luc has a Doctorate in Electrical Engineering from the University of New Brunswick and a Master of Science degree in Electrical Engineering from l'Université de Montréal.

Alex replaces Gerry Chan, while Jean Luc replaces Bob Kuley.

CRC's mission is to be the federal government's centre of excellence for communications R&D, ensuring an independent source of advice for public policy purposes. CRC also aims to help identify and close the innovation gaps in Canada's communications sector by:

- *engaging in industry partnerships;*
- *building technical intelligence;*
- *supporting the information and communications technologies industry*